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Autumn Long-distance Movements of Male Japanese Sika deer *Cervus nippon yesoensis* in Western Hokkaido, Japan

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Abstract

We examined the ranging behaviors of three male Japanese sika deer *Cervus nippon yesoensis* in western Hokkaido (42°N, 141°E), Japan, from 2003 to 2009. All three deer exhibited similar patterns of long-distance movements in the autumn. They left residence areas between 17 September and 16 October during the rutting season. Their direction of movement appeared to be eastward, and total movement distances ranged from 7 to 26 km. The males tended to return to their residence areas between 10 November and 27 January.

Key words: male, migration, range, rutting season, sika deer

Introduction

Movement patterns evolved among animals in response to spatial differences of habitat qualities for their reproduction or survival. For ungulate species, seasonal movements often serve as an adaptation to both shifting food resources and predator avoidance (Gates *et al*. 2005). Snow can also be an essential factor affecting seasonal movements, particularly for ungulates living in cool habitats (e.g., Mauri *et al*. 2006, Ramanzin *et al*. 2007, Fieberg *et al*. 2008). Most studies on seasonal movements of Japanese sika deer *Cervus nippon* have been conducted in cool-temperate areas that experience heavy snow in the winter (e.g., Takatsuki *et al*. 2000, Uno and Kaji 2000, Sakuragi *et al*. 2003, Igota *et al*. 2004). These studies have revealed that the movements between summer and winter ranges are chiefly driven by limitation of food accessibility and restriction of activity by snow cover. However, these studies have primarily addressed in females, and information of males remains quite limited. The movements of male sika deer may be affected by a specific set of factors that differ from those driving females' movements. Therefore, we assessed the movement patterns of three male Japanese sika deer individuals in a cool-temperate area of western Hokkaido, Japan. Although the number of study subjects was small, this is the first report concerning the ranging behavior of sika deer inhabiting western Hokkaido. In addition, the three males exhibited similar long-distance movements in autumn, which has not yet been reported for Japanese sika deer.

Methods

The study was conducted in Tomakomai and Atsuma in western Hokkaido, Japan (42°N, 141°E), from 2003 to 2009. At the study site, continuous snow cover began from early December to early January and ended in March (data for 2003 to 2009 from the Japan Meteorological Agency). The subject deer resided in three main areas (Fig. 1). The first area consisted of the Tomakomai Experimental Forest of Hokkaido University (TOEF), approximately 70% of which is covered by deciduous broad-leaved forest, and the remainder is primarily conifer plantations. No crop fields are planted in the TOEF. The altitude of the area ranges from 5 to 90 m above sea level (a.s.l.). Mean monthly temperature during the coldest month (January) was –6°C, and maximum snow depth was 70 cm. TOEF has been designated a Wildlife Protection Area, and hunting and deer control measures are not permitted. The deer population density in the TOEF between 2003 and 2006 ranged from 2 to 16 individuals/km^2 (Agetsuma *et al*. 2007). The second area ranged from the east coast of Lake Utonai to the Tomatoh district (TOMATOH) and consisted of broad-leaved forest, swamp grassland, greenfield areas for industrial use, industrial sites, and crop fields (around 10 m a.s.l.). The region also contains railways and many public roads. In some areas of TOMATOH, deer hunting and control measures are not permitted. The maximum snow depth observed during the study period was 40 cm in 2009. The third area was a suburb of Atsuma Town (ATSUMA), which mainly consisted of broad-leaved forest but also included crop fields and conifer plantations. The altitude ranged from 40 to 90 m a.s.l. Mean monthly temperature during the coldest month (January) was –7°C (data from the Japan Meteorological Agency). The maximum snow depth

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observed during the study period was 40 cm in 2008. Deer hunting and control measures are conducted in this area.

Three male Japanese sika deer *C. n. yesoensis* (M1, M2, and M3) were captured in the TOEF during winter from 2003 to 2006. All deer had antlers with four or five points; thus, they were all estimated to be mature adults (Table 1). M3 was injured and lost its left forearm during capture. We conducted antisepsis and hemostasis, and treated the deer with antibiotics. Radio collars were attached to all deer (120 g: ATS Co., Ltd.), which were then released at the capture sites. After then, the deer were located by triangulation using a three-element Yagi antenna and a radio receiver within 20 min, and also by direct observation. The mean error distances of triangulation in the TOEF ranged from approximately 80 to 90 m (Onishi 2003, Aburakawa 2006). The interval of the deer locations mainly ranged between 1 and 7 days. When radio waves could not be detected for several consecutive days, those around the previous ranging areas were searched intermittently. In total, we obtained 156 fixes for M1, 357 for M2, and 903 for M3. All location data were analyzed using Geographical Information System (ArcGIS ver. 9.3, Esri Inc.).

Emigration in the autumn was defined as follows. First, the summer range was calculated as a 90% minimum convex polygon (MCP) using fixes from June to August in a given year. When a deer moved more than 3 km away from the nearest edge of the MCP, it was considered to have emigrated from the residence area. Similarly, immigration (return) to the residence area was defined as when a deer entered within 3 km of the MCP. The distances of emigrations were calculated as the lengths between the farthest fix and the edge of the MCP.

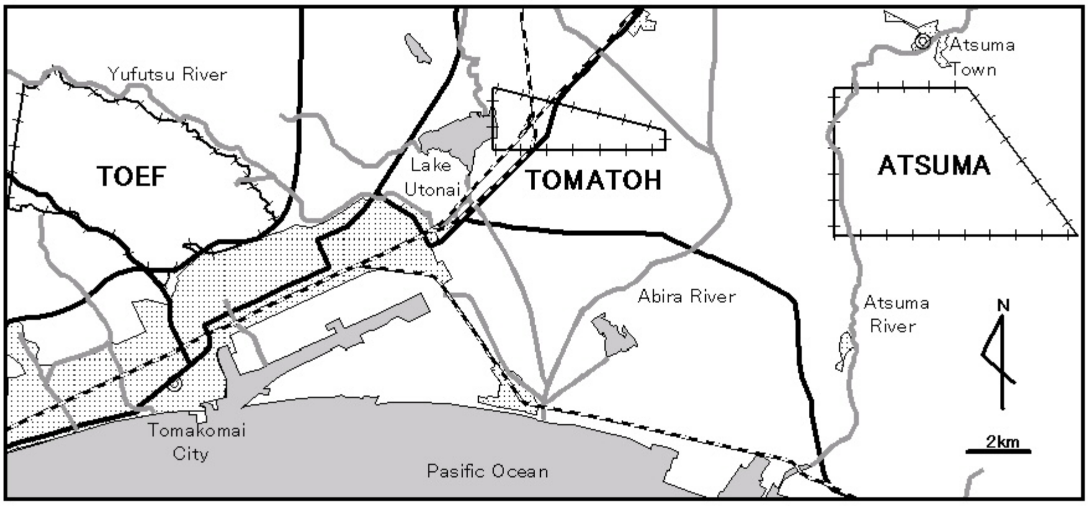


Fig. 1. The study site included three areas where subject deer primarily resided (TOEF, TOMATOH, and ATSUMA). Shaded areas indicate the sea and main lakes, and hatched areas indicate human residential zones. Solid, gray, and black-and-white lines indicate National Routes, major rivers, and railways, respectively. Double circles indicate the locations of Tomakomai City Hall and Atsuma Town Hall.

Table 1. Subjects, date of immigration and emigration, and distance of movement

Subject	Date of capture	Body weight (kg)	Head and body length (cm)	Number of antler points (left, right)	Residential area	Immigration date	Emigration date	Distance of movement (km)
M1	5 Jan. 2006	>127	187	5,4	TOEF	–	17 Sep. 2006	>9.5
M2	11 Mar. 2003	–	193	4,4	TOEF	–	1 Oct. 2003	–
					TOEF	12 Nov. 2003	24 Sep. 2004	>8.5*3
M3	1 Mar. 2005	–	195	4,4	TOEF	–	16 Oct. 2005	10.9
					TOEF	10 Dec. 2005	26 Sep. 2006	>26.1
					TOEF	27 Jan. 2007*1	8 Oct. 2007	26.1
					TOMATOH	–*2	30 Sep. 2008	6.7
					TOMATOH	10 Oct. 2008	–	–

*1: The deer individual may have returned to the residential area on an earlier date.
*2: Residence area shifted between 2007 and 2008.
*3: Distance between the last summer range and the location where the collar was found.

Results and discussion

M1 was captured in the TOEF on 5 January 2006. It stayed within a 1.8-km radius in the TOEF until 12 September 2006 (Fig. 2). However, on 17 September, it was killed in a traffic accident east of Lake Utonai. In total, M1 moved 9.5 km eastward from its summer range in the TOEF.

M2 was captured on 11 March 2003 in the TOEF. It remained within a 2.6-km radius in this area until 28 September 2003 (Fig. 3a). After 1 October 2003, its radio waves could not be detected around the TOEF. Therefore, we assumed that it had rapidly left the summer range.

M2 immigrated to the original area in the TOEF by 12 November 2003 and stayed there within a 2.4-km radius until 23 September 2004 (Fig. 3b). Subsequently, it was lost again. Its radio collar was found in a bush on 27 October 2005, south of Lake Utonai, which was 8.5 km east from its last summer range.

M3 was captured on 1 March 2005 in the TOEF and remained within a 1.4-km radius until 15 October 2005 (Fig. 4a). It then moved 10.9 km from its summer range to the eastern shore of Lake Utonai (TOMATOH) until 27 October and remained there for about 1 month.

By 10 December 2005, M3 returned to TOEF and stayed within a 2.9-km radius until 25 September 2006 (Fig. 4b). Subsequently, it emigrated and moved 26.1 km from the summer range to ATSUMA between 26 September and 16 October 2006. However, it was lost after 17 October 2006.

M3 was found again on 27 January 2007 in the TOEF, although it may have returned earlier. It stayed within a 2.2-km radius in this area of the TOEF until the morning of 4 October (Fig. 4c). Then, from the night of 4 October to 1 November 2007, it began to move 26.1 km eastward from the summer range to ATSUMA. It overwintered and remained there until 24 April 2008. It then moved to TOMATOH on 8 May 2008 (Fig. 4d).

M3 stayed in TOMATOH within a 1.2-km radius until 30 September 2008. It then moved 6.7 km eastward from the summer range to ATSUMA from 28 September to 5 October (Fig. 4e). It remained there for 3 days and soon returned to TOMATOH on 10 October 2008. It stayed in TOMATOH until 25 February 2009 (Fig. 4f), and its radio collar was found on the ground in TOMATOH on 2 June 2009.

Routes of the long-distance movement in M3 between TOEF, TOMATOH, and ATSUMA appeared to be very stable (Fig. 4). Its residence areas were also stable but shifted from TOEF (2005, 2006, and 2007) to TOMATOH (2008 and 2009).

Although we only studied three individual male Japanese sika deer, they all exhibited long-distance movements during seven autumn seasons (Figs. 2–4). All three males left their residence areas between 17 September and 16 October (Table 1). Their general direction of movement appeared to be eastward, and total movement distances ranged from 7 to 26 km. M2 and M3 returned to their residence areas between 10 October and 27 January, although M3 returned to its residence area during the spring of 2009 (Table 1; Fig. 4d). These results show a possibility that some male Japanese sika deer have migratory behaviors especially in autumn in the study area. The autumn long-distance movements might relate their reproductive behaviors because the movements were coincident with the beginning of rutting season (from late September to November; Abe *et al*. 1994; Agetsuma personal observation) before snowfall.

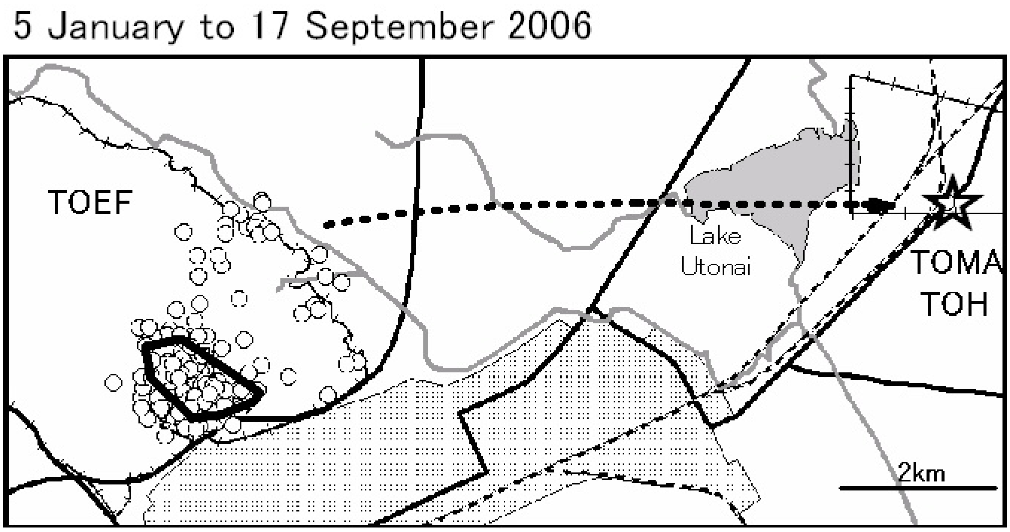


Fig. 2. Movement patterns of deer M1. Circles indicate location points of M1 from 5 January to 17 September 2006 (n = 156). The polygon indicates the summer range (90% MCP from June to August) of M1. The dashed arrow indicates the direction of movement. The open star indicates the location of the death of M1.

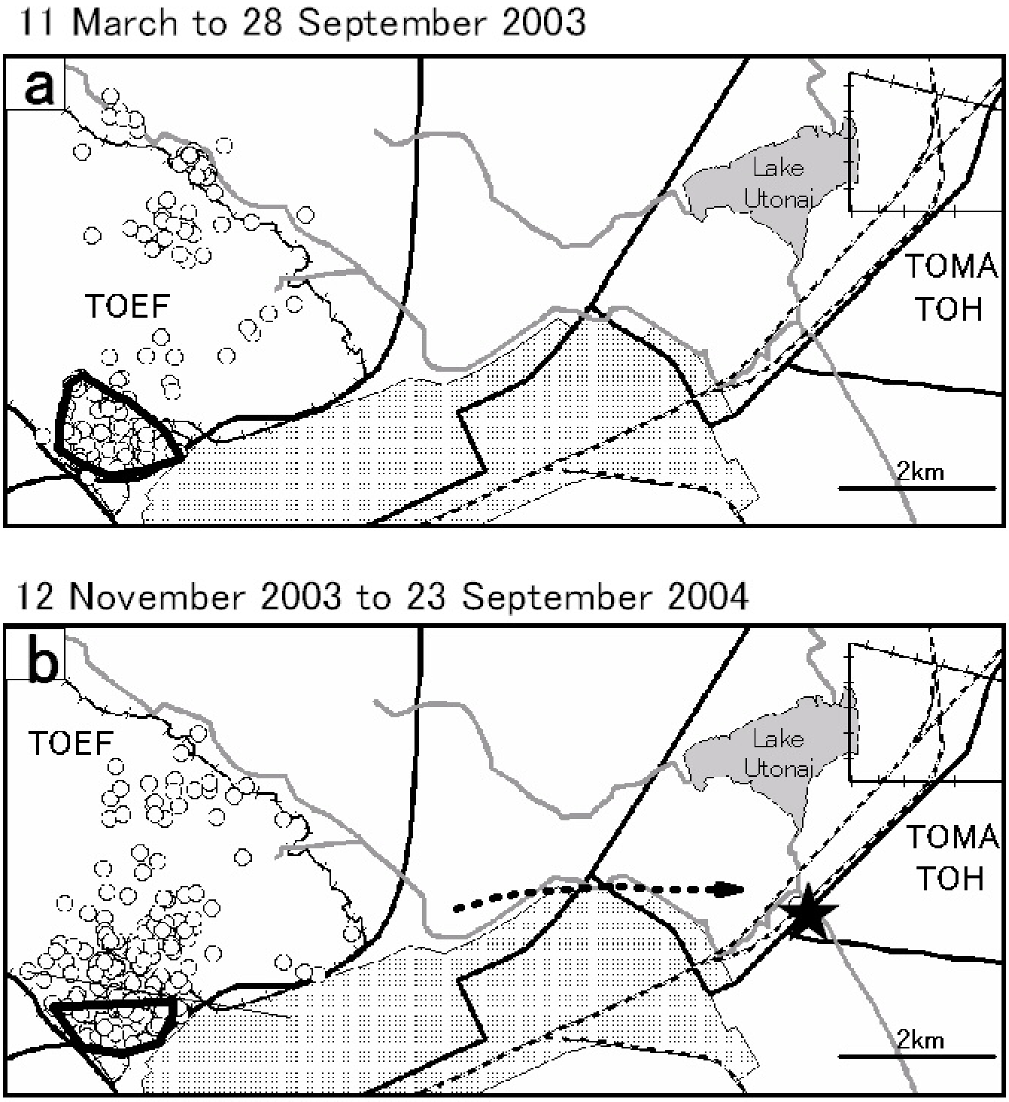
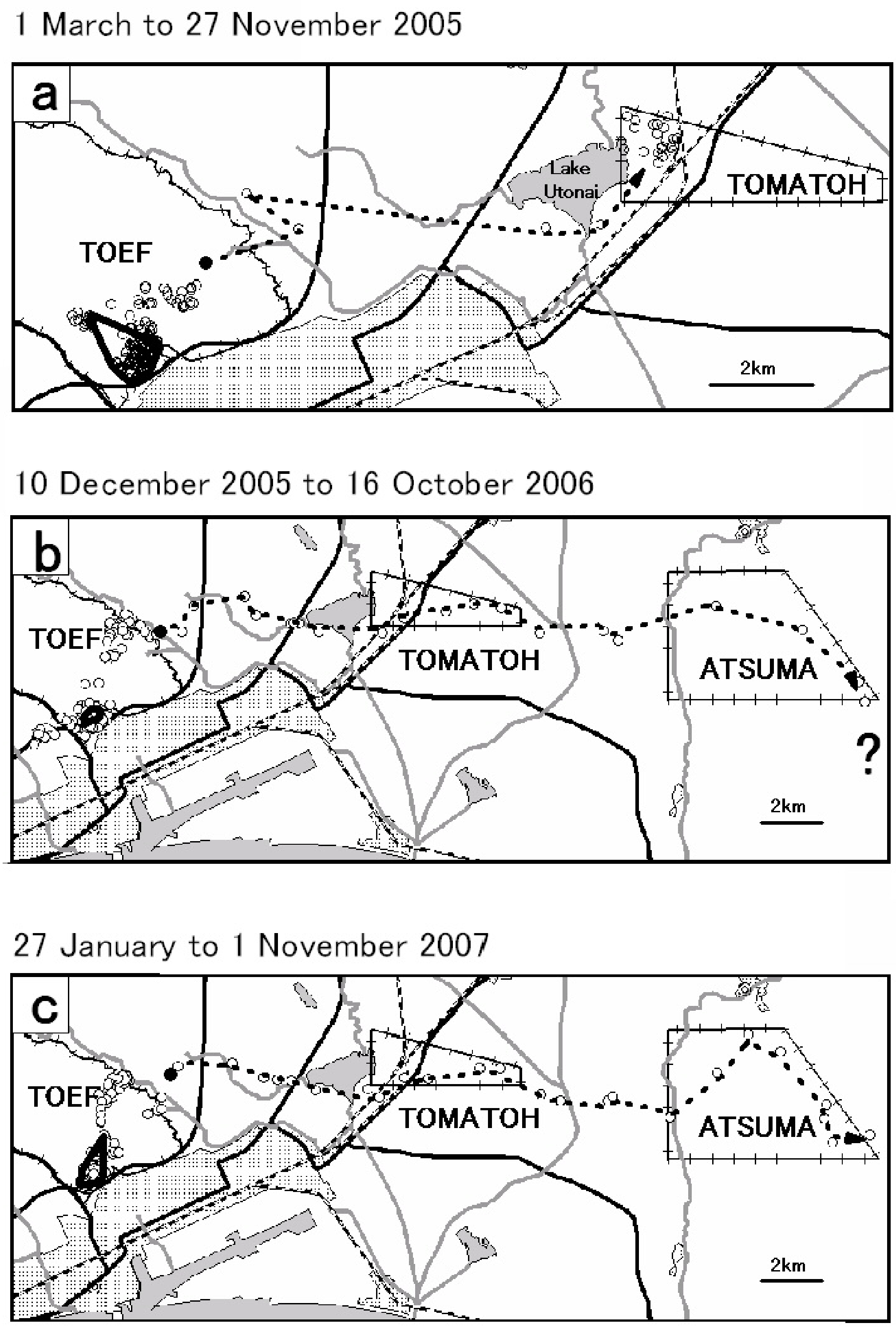


Fig. 3. Movement patterns of deer M2. Circles indicate location points of M2 from (a) 11 March to 28 September 2003 (n = 146) and from (b) 12 November 2003 to 23 September 2004 (n = 210). Polygons indicate the summer ranges of M2. The dashed arrow indicates the direction of movement. The solid star indicates the location where the radio collar was dropped.


1 March to 27 November 2005
a
Lake
Utonai
TOMATOH
TOEF
2km
10 December 2005 to 16 October 2006
b
TOEF
TOMATOH
ATSUMA
?
2km
27 January to 1 November 2007
c
TOEF
TOMATOH
ATSUMA
2km

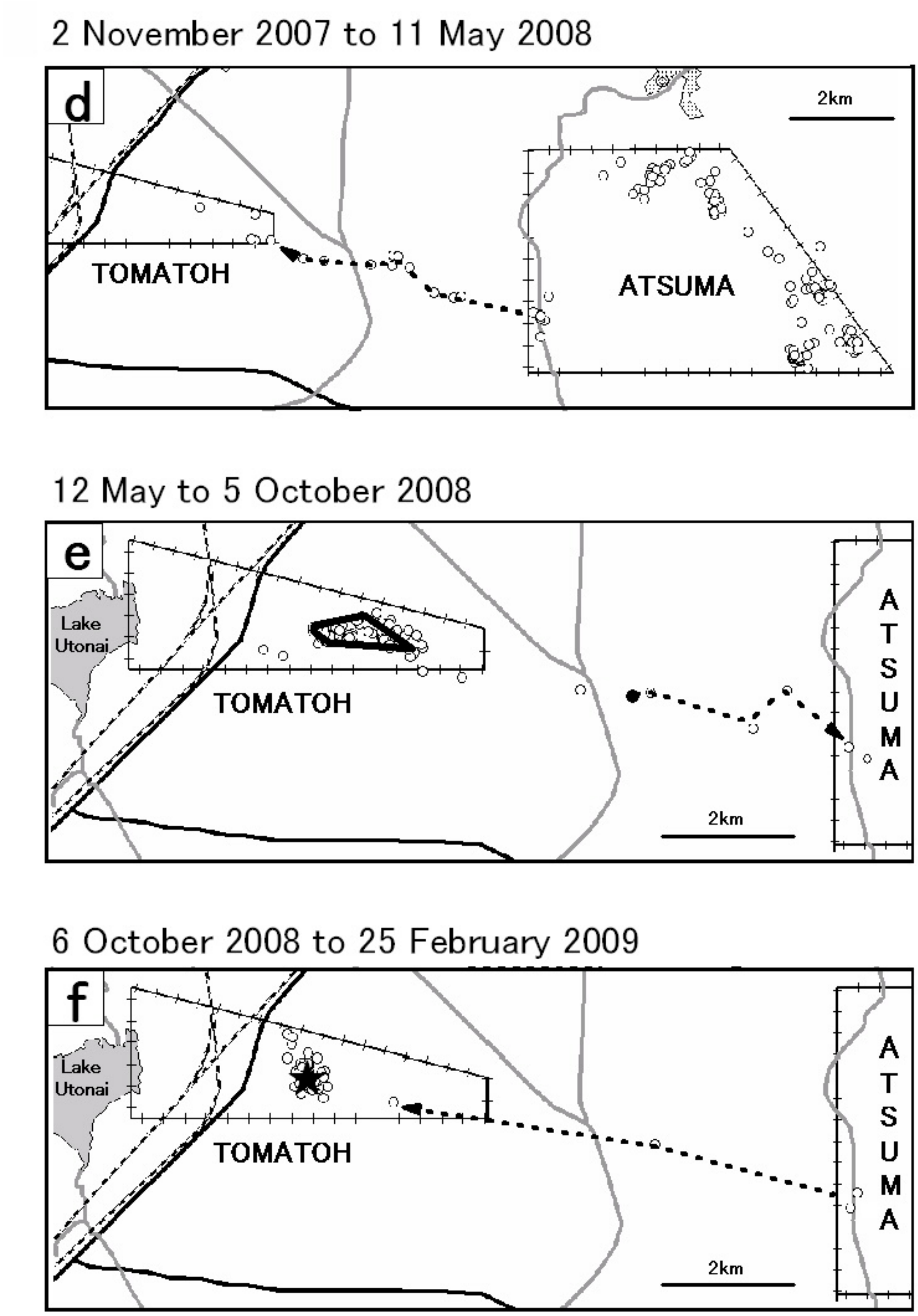


Fig. 4. Movement patterns of deer M3. Circles indicate location points of M3 from (a) 1 March to 27 November 2005 (n = 181), (b) 10 December 2005 to 16 October 2006 (n = 198), (c) 27 January to 1 November 2007 (n = 257), (d) 2 November 2007 to 11 May 2008 (n = 128), (e) 12 May to 5 October 2008 (n = 85), and (f) 6 October 2008 to 25 February 2009 (n = 53). Polygons indicate the summer ranges of M3. Black circles in (a), (b), (c), and (e) indicate locations on emigration dates. The dashed arrow indicates the direction of movements. The solid star indicates the location where the radio collar was dropped.

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